

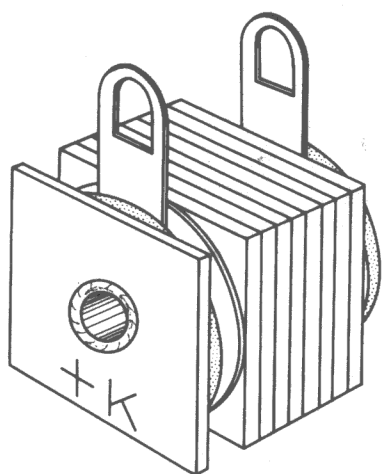
ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 17

RECTIFICATION EXPERIMENTS



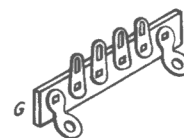
RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.



selenium rectifier



terminal strips



All the parts in Kit 9 are listed below. Check the parts you receive against this list. Make sure you have the correct quantity of every item. If a part is either missing or defective upon arrival, request a replacement from Department R, Home Study School, RCA Institutes, Inc., 350 West 4th Street, New York 14, N.Y. *Your request must include your name and student number, the complete name and description of the part copied from the Item column below, the Quantity missing or defective, and the reason you are asking for a new part.*

KIT 9

BILL OF MATERIALS

Quantity	Item	Quantity	Item
1	6X5GT electron tube	1	Resistor, 5,000-ohm 10-watt
1	Electrolytic capacitor, 40 μ f x 20 μ f x 20 μ f at 300 volts, 25 μ f at 25 volts	1	Resistor, 47,000-ohm 1-watt
1	Selenium rectifier, 20 ma.	2	Five-foot lengths of #20 solid tinned pushback wire
1	Power transformer	1	Support bracket for signal generator
1	Potentiometer, 500 k-ohm with 3/8" nut	1	6' power cord with male plug attached
<i>The following hardware for the signal generator is contained in a separate envelope:</i>			
11	#6-32 x 1/4" round-head machine screw	22	#6-32 nut
2	#6-32 x 1/4" binding-head machine screw	2	#4-36 nut
2	#4-36 x 3/16" round-head machine screw	1/4 lb	50-50 rosin-core solder
1	#6-32 x 1" round-head machine screw	1'	Spaghetti cloth
10	#6 x 1/4" binding-head self tapping screw	3	#6 flat washers
23	#6 lock washer	3	#6 ground lug
1	Round knob	2	#4 lock washer
		2	Indicator knob
		1	Pointer knob
		1	9-pin miniature tube socket
		1	terminal strip (E)
		1	terminal strip (F)
		1	terminal strip (G)
		4	Rubber feet
		4	#6 x 3/8" sheet-metal screws
		1	Rubber grommet 1/2" O.D.
		2	Rubber grommets 3/8" O.D.
		1	3/8" snap plug

If you get a part slightly different from a part described in this list, the substitute part will not interfere electrically or mechanically with your experiments or equipment.

Experiment Lesson 17

OBJECT

1. To study the action of a diode in rectification.
2. To study half-wave and full-wave rectification in a power supply.

INFORMATION

In this experiment lesson, you will find that the theory of diodes and rectification that you have been studying is borne out by the experiments you will perform.

In this course, you first used a rectification circuit after you assembled the a-c section of the multimeter. The two crystal diodes that you wired into the multimeter made it possible for you to measure a-c with a meter movement that was designed for d-c. Now you will take a closer look at the rectification action. You will also wire and study the rectifier of the power-supply section of your 6-tube superheterodyne receiver. A complete schematic diagram of the receiver is shown at the end of this experiment lesson.

EQUIPMENT NEEDED

Receiver chassis
Octal tube socket
Soldering iron and solder
Multimeter
Hardware
Tools
20-ma selenium rectifier
Wire
6X5GT tube

10,000-ohm 5-watt resistor (from Kit 7)
47,000-ohm resistor
Wooden board, bench, or table

EXPERIMENT 17-1

To study rectification action.

Note: The experiment that follows must be done on an insulated surface. This may be a wooden board, bench, or table.

Procedure.

Step 1. Cut a 4-inch length of hookup wire and remove $\frac{1}{4}$ inch of insulation from each end.

Step 2. Solder one end of the 4-inch lead to the cathode (k or +) terminal of the selenium rectifier.

Step 3. Solder the other end of the 4-inch lead to one end of the 330-ohm resistor on the resistor breadboard.

Step 4. Clip the positive terminal of the 4-cell 6-volt battery to the anode terminal (not marked) of the selenium rectifier.

Step 5. Set up the multimeter for service on the 10-milliamperere d-c range. Connect the meter positive test lead to the free end of the 330-ohm resistor. The portion of the circuit that is already completed should look like Fig. 17-1. If all of the connections agree with the illustration, continue with the next step.

Step 6. With the negative meter test prod, make a brushing contact with the negative battery clip. At the same time, watch the meter dial. If the meter needle moves normally, connect the negative battery clip to the

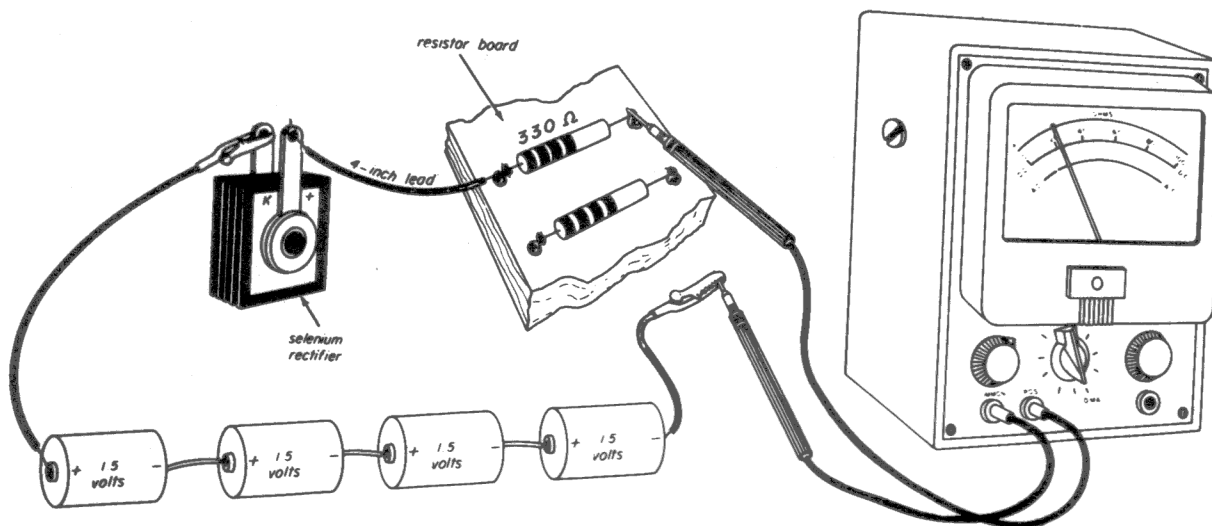


Fig. 17-1

negative test prod. Record the current reading here:

3.6 ma

Step 7. Disconnect the battery from the circuit.

Step 8. Connect the negative battery clip to the rectifier anode.

Step 9. Connect the meter's positive test prod to the positive battery clip, and the negative test prod to the free end of the resistor. Record the current reading here:

0

Discussion. In this experiment, you have found that the diode rectifier acts very much like a one-way street for electrons. In your reading in Step 6, you found that the current was about 4.0 ma, while in Step 9 the reading was so very small that practically no current was flowing. This action has been compared with that of a valve. In fact, in England, electron tubes that act in the same way (such as the 6X5GT tube you will use in this lesson) are called *valves*.

Warning: While performing the experiments in this lesson, be careful — do not take chances. An electric shock is not pleasant at any time, and the voltages that you will be working with can hurt — can even kill. Play safe by playing smart. When the a-c cord is connected to the a-c cord line-voltage source, make no moves, touch nothing, unless you know that what you are doing is right. To be sure, most shocks do not amount to much. But no one knows ahead of time which shock is the shock that will be fatal. Ask any old timer — for it is the old timer who can tell you about the others who aren't around.

In previous experiment lessons, you temporarily wired the power transformer leads to several terminal strips. This was necessary in order that you could perform experiments that required the use of the transformer. In this experiment lesson, you will start the permanent wiring of the power-supply section of your 6-tube a-c operated superheterodyne receiver. Figure 17-2 shows the pictorial view of the underside of the chassis as it should look at this time. To make room for mounting the tube socket, it will be necessary to remove one terminal strip and to move another to a different place on the chassis.

JOB 17-1

To change the position of the terminal strip to which the a-c line cord is soldered.

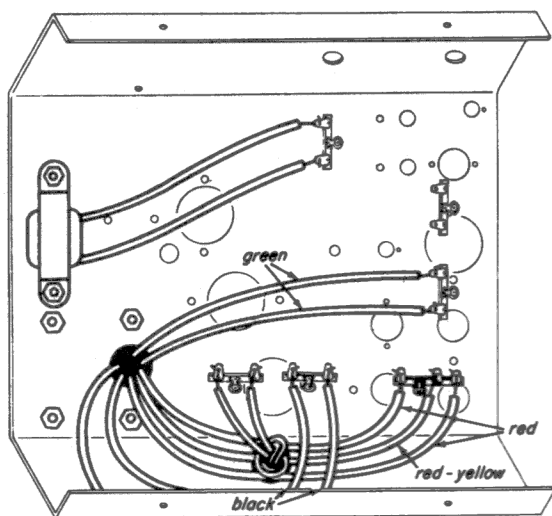


Fig. 17-2

Procedure.

Step 1. With your screwdriver, unfasten the line-cord terminal strip.

Step 2. Remove the power-transformer mounting nut shown in Fig. 17-3. Slip the mounting lug of the line-cord terminal strip over the transformer mounting screw. Make sure that the terminal strip faces in the direction shown in Fig. 17-3, and fasten it in place with the mounting nut that you just removed. If necessary, loosen the knot on the line cord and work it along the wire to the grommet. Retighten the knot.

JOB 17-2

To unsolder the transformer primary leads and to remove the terminal strip from the chassis.

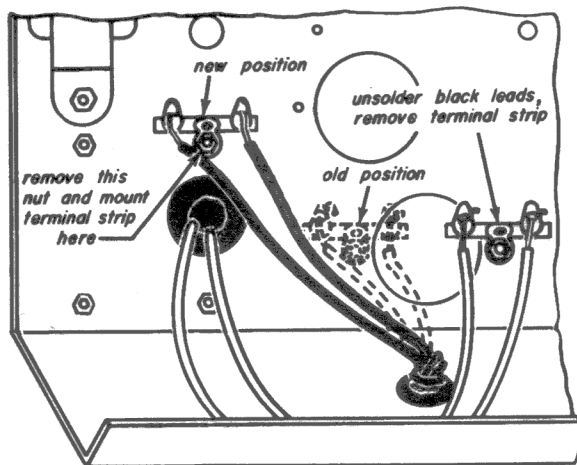
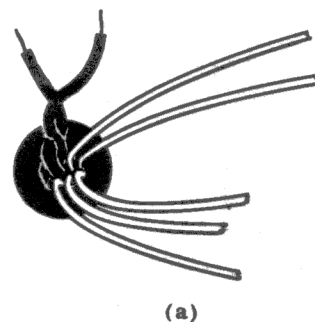
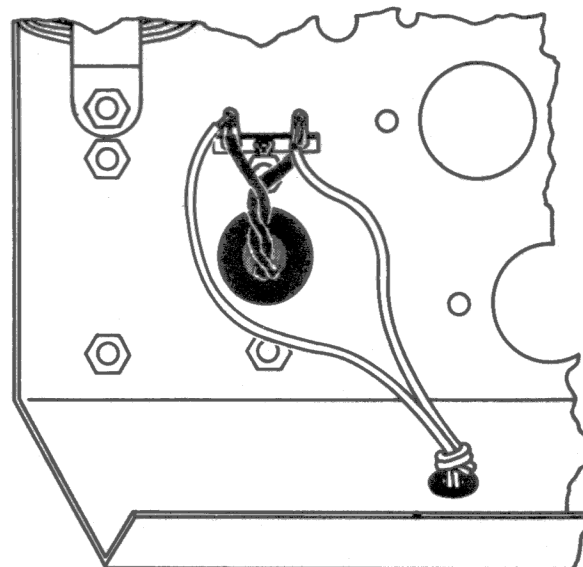


Fig. 17-3



(a)



(b)

Fig. 17-4

Procedure.

Step 1. Unsolder the transformer primary leads from the terminal strip.

Step 2. Unfasten and remove the terminal strip from the chassis.

JOB 17-3

To solder the primary leads of the transformer permanently to the a-c line-cord terminals.

Procedure.

Step 1. Take both primary leads (black) and cut them so that the length of each lead is $2\frac{1}{4}$ inches.

Step 2. Strip off $\frac{1}{4}$ inch of insulation from each lead.

Step 3. Twist the leads together as shown in Fig. 17-4a.

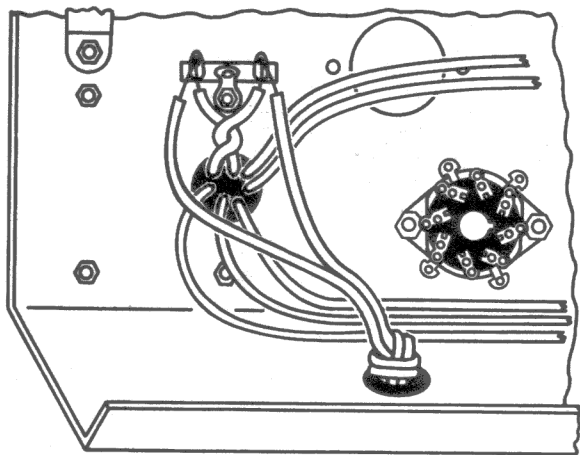


Fig. 17-5

Step 4. Connect and solder the primary leads to the line-cord terminal strip. Run the wires neatly, close to the chassis, as shown in Fig. 17-4b. This is called dressing the leads. Placement of leads is as important as neatness. Sometimes, a wire is run so that it does not come close to another wire or circuit, and sometimes wires have to be kept close to the chassis and sometimes away from the chassis. So, in this and following lessons, when you are told to dress wires in a certain way, be sure to run them exactly as you are instructed—then they will be dressed correctly.

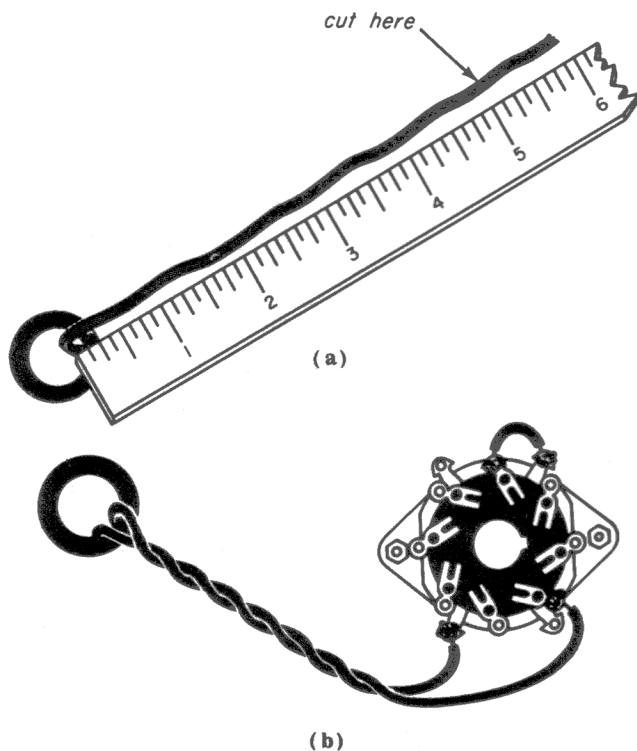


Fig. 17-6

JOB 17-4

To mount an octal-tube socket for the rectifier tube.

Procedure.

Step 1. Turn the receiver chassis upside down on the 2" x 4" wooden blocks. Place the octal socket over the socket mounting holes on the chassis, as shown in Fig. 17-5. See that the keyway is farthest from the power transformer.

Step 2. Fasten the socket to the chassis with two $\frac{1}{4}$ inch 6-32 screws, two #6 lock-washers, and two 6-32 nuts.

JOB 17-5

To solder the filament leads of the power transformer so that 6.3 volts is applied permanently to terminals 2 and 7 of the tube socket, as shown in Fig. 17-6

Procedure.

Step 1. Unsolder the two green 6.3-volt secondary leads from the terminal strip to which they are connected.

Step 2. From the rubber grommet, measure off 5 inches on one green lead, as shown in Fig. 17-6a, and remove the excess wire with your cutting pliers. Strip $\frac{1}{4}$ inch of insulation from the end of this lead.

Step 3. From the other green lead, measure off $4\frac{1}{2}$ inches and remove the excess. Strip $\frac{1}{4}$ inch of insulation from the end of this lead.

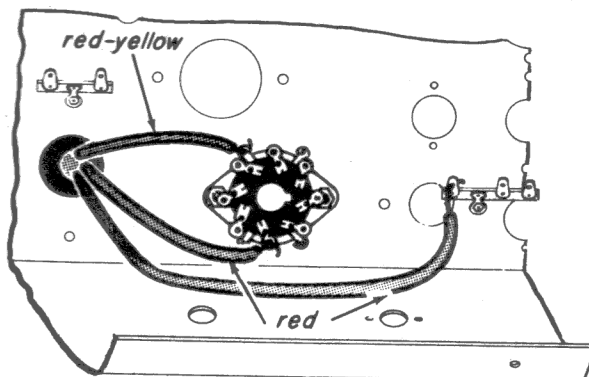


Fig. 17-7

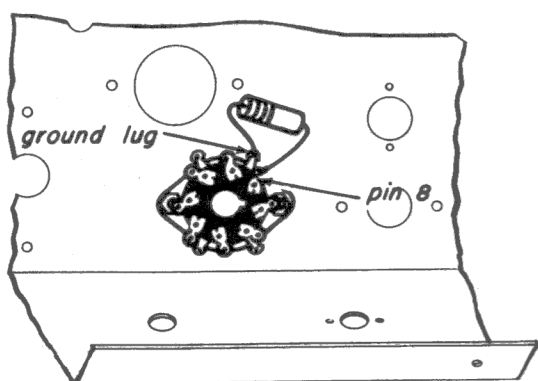


Fig. 17-8

Step 4. Twist these leads together and dress them as shown in Fig. 17-6b.

Step 5. Solder the shorter lead to the ground lug and the longer lead to terminal 2 of the tube socket, as shown in Fig. 17-6b. Make permanent connections.

Step 6. Take a 1-inch piece of bare wire. Solder this wire between terminal 7 of the tube socket and the ground lug nearest to it.

JOB 17-6

To connect one half of the high-voltage secondary winding to the power-supply circuit.

Procedure

Step 1. Unsolder the red-yellow high-voltage secondary lead from the terminal strip to which it is now connected.

Step 2. Cut and dress the red-yellow lead so that it may be connected to the ground lug at the tube socket, as shown in Fig. 17-7. Strip $\frac{1}{4}$ inch of insulation from the end of

the lead and solder it temporarily to the ground lug.

Step 3. Unsolder *one* red high-voltage secondary lead from the terminal strip to which it is now connected.

Step 4. Cut, strip, dress, and solder the red lead permanently to terminal 3 of the octal tube socket.

JOB 17-7

To connect the 47,000-ohm resistor between terminal 8 of the tube socket and ground.

Procedure

Step 1. Solder one end of the 47,000-ohm resistor to terminal lug 8 of the tube socket; make a temporary connection.

Step 2. Solder the other end of the resistor temporarily to the ground lug of the tube socket, as shown in Fig. 17-8.

Discussion. You have now assembled a simple half-wave rectifier circuit, as shown in the schematic diagram in Fig. 17-9. Unlike most rectifier circuits used to supply d-c power for radio and television receivers, this circuit has no filter. In the next lesson, you will add a filter to the circuit and see what effect it has on the voltage output. At this time, you will study only rectification.

Before applying a-c power to the circuit you have just completed, it should be tested to determine whether or not a wiring mistake has been made. When you have completed the tests and know that the circuit is correct, start the experiments.

Testing Procedure. These tests are made without any a-c or other power applied to the circuit. Figure 17-10a shows 6 test points marked on a schematic of the circuit you wired. Figure 17-10b shows these same test points marked on the picture diagram of the circuit. At each of the test points, measure the resistance between that point and ground (chassis). Then measure the resistance between A and B (across the prongs of the line-cord plug). Compare the values you obtain with those in Table A. If there is a difference of more than 20 percent between your

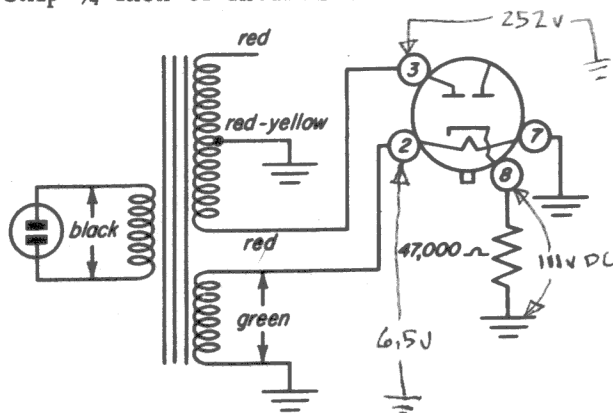


Fig. 17-9

2.20 / .040
 2.4 / .16
 47000 / 940000
 47000 / 94000
 13 / 260
 13 / 26
 10.4

reading and the value given in the table, examine your wiring for possible mistakes and then correct any mistakes. If a short is shown by your reading, look for pieces of wire, solder drippings, or uninsulated lead making a connection between a wire or a soldering lug and chassis, between soldering lugs, or between two wires. If there is an open—if the meter shows an infinite resistance where there should be none—look for an unsoldered or poorly connected wire.

After you have performed these tests and are certain that there are no mistakes, proceed with the experiment.

TABLE A - RESISTANCE MEASUREMENTS

Test Point	Resistance (ohms)	
A and chassis	∞	∞
B and chassis	∞	∞
C and chassis	240	245
D and chassis	245	245
E and chassis	0.1	0.2
F and chassis	43,000	47,000
A-B (across plug prongs)	8	13

EXPERIMENT 17-2

To study the rectifier action of the simple electron tube half-wave rectifier circuit shown in Fig. 17-9.

Procedure

Step 1. Place the chassis upside down on the 2" x 4" wooden blocks.

Step 2. Plug the a-c line cord into the a-c outlet.

Step 3. Between pin 2 of the tube socket and ground, measure the a-c voltage and record it here:

6.5v

Step 4. Using the 300 VAC range of your meter, measure the voltage between pin 3 and ground (chassis) and record it here:

252v

Step 5. With the meter on the same range, measure between pin 8 of the tube socket and ground. If there is any reading, record it here:

0

Step 6. Switch the meter over to the 500 VDC position and measure between pin 8 of the tube socket and ground. If there is any reading, record it here:

0

Step 7. Place the 6X5GT tube in the rectifier socket, which is mounted on the receiver chassis. Make sure that you line up the key of the socket with the keyway of the tube and then insert the tube in the socket.

Step 8. Allow the tube to heat up for about 45 seconds. Then place the negative test prod of the meter against chassis and the positive test prod to terminal 8 (cathode) of the rectifier socket. Record the voltage here:

111v D.C.
~~262v~~

Step 9. Remove the line cord from the a-c outlet.

Discussion. From the voltage tests that you made, you know that the heater voltage is approximately 6.3 volts a.c. You know that the voltage between terminal 3 and ground (chassis) is about 230 volts a.c. You know, too, that without the rectifier operating in the socket, there was no voltage drop between cathode (terminal 8) and ground. This was because the circuit was incomplete, and no voltage drop can exist in a resistor unless there is also current flow. So you can see that by adding the rectifier to the circuit, you have completed the circuit and produced a current flow that is in one direction and that you were able to measure with a d.c. meter. Therefore, the rectifier has succeeded in converting an alternating current into a direct current.

EXPERIMENT 17-3

To study the effect of full-wave rectification on the d-c output of the rectifier.

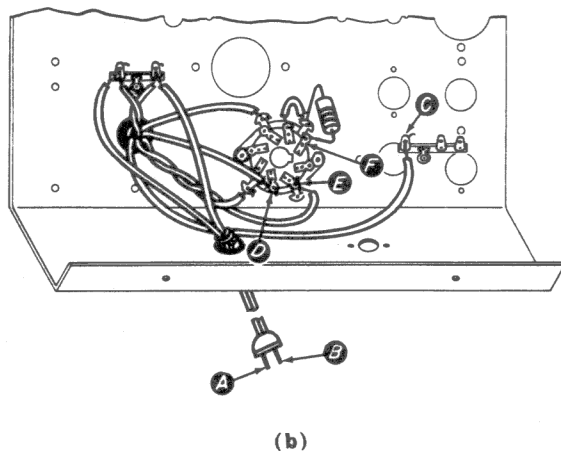
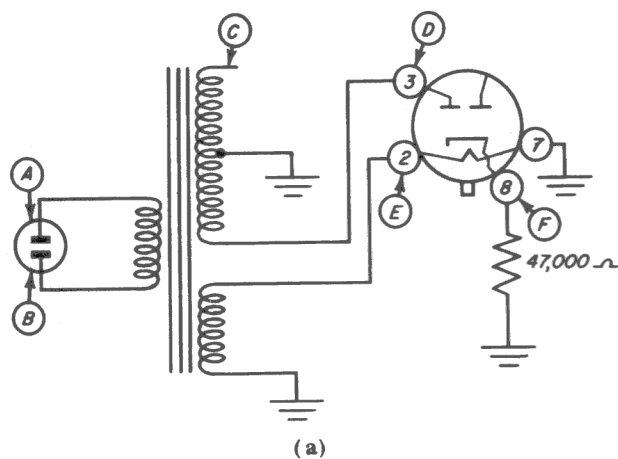


Fig. 17-10

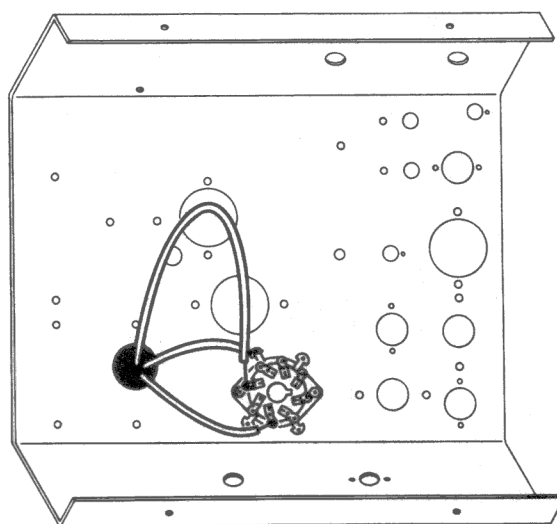


Fig. 17-11

Procedure.

Step 1. Unsolder the free end of the high-voltage secondary from the terminal strip and solder it instead to terminal 5 of the tube socket. Do not cut it; use the entire length of wire and make a temporary connection. If this is correctly done, one red high-voltage secondary lead should be connected at terminal 3 and the other red high-voltage secondary lead to terminal 5 of the tube socket, while the red and yellow lead should still be connected to chassis ground. Your wiring should look like that shown in Fig. 17-11. The schematic diagram of the full-wave power supply is shown in Fig. 17-12. If the wiring is correct, proceed with the next step.

Step 2. Plug the line cord into the a-c outlet. Allow the tube about 45 seconds to heat up.

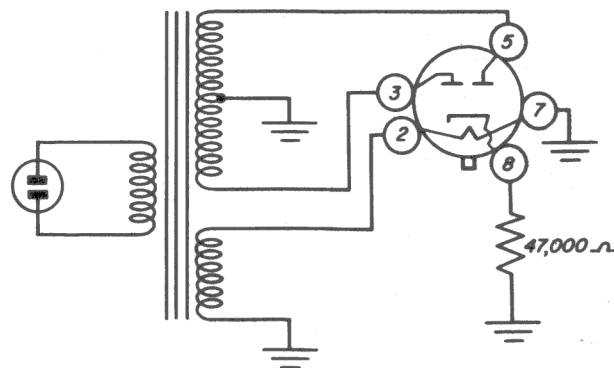


Fig. 17-12

Step 3. Your meter should still be set up for operation on the 500 VDC range.

Step 4. Measure the voltage between cathode (terminal 8) and ground (chassis). Record the voltage here:

215 VDC

Step 5. Remove the line cord from the a-c outlet.

Discussion. If you compare the voltage readings you obtained in Experiment 17-2 with those that you just now recorded, you will find that full-wave rectification increases the voltage output. The output voltage for a half-wave rectifier is about 110 volts, while the output for a full-wave rectifier is approximately 225 volts. Thus, it is possible with the same value of a-c input to get a greater d-c output with full-wave rectification than you can get with half-wave rectification.

EXPERIMENT 17-4

To study the effect of a change in load upon the output voltage of a full-wave rectifier.

Procedure

Step 1. Unsolder the *grounded end* of the 47,000-ohm resistor.

Step 2. Insert the a-c line cord in the a-c power source. Allow 45 seconds for the tube to warm up.

Step 3. Set the FUNCTION switch of your multimeter to DC and the RANGE switch to 1 AMP.

Step 4. Connect the negative test prod to the chassis and connect the positive test prod to the open end of the 47,000-ohm resistor. If you cannot get a reading on this range, turn the range switch to a usable current

scale and record the load current here:

4.4 ma

Step 5. Remove the line cord from the a-c outlet.

Step 6. Unsolder and remove the 47,000-ohm resistor.

Step 7. Solder one end of the 10,000-ohm 5-watt resistor temporarily to terminal 8 of the tube socket.

Step 8. Solder the other end of the 10,000-ohm resistor temporarily to the grounding lug.

Step 9. Insert the a-c line cord into the a-c outlet and allow 45 seconds for the tube to warm up.

Step 10. Set up your multimeter on the 500 VDC range.

Step 11. Place the negative test prod on the chassis and the positive test prod on the cathode (terminal 8) of the tube socket). Record the voltage here:

207 v

Step 12. Remove the line cord from the a-c outlet.

Step 13. Unsolder the *grounded end* of the 10,000-ohm resistor.

Step 14. Insert the line cord into the a-c outlet and wait 45 seconds for the tube to warm up.

Step 15. Set the FUNCTION switch of your multimeter to DC and the RANGE switch to 1 AMP.

Step 16. Connect the negative test prod to the chassis and connect the positive test

prod to the open end of the 10,000-ohm resistor. If you cannot get a reading on this range, switch to a usable current range and record the load current here:

21 ma

Step 17. Remove the line cord from the a-c outlet.

Step 18. Unsolder and remove the 10,000-ohm resistor.

Discussion. When the load was 47,000-ohms, the d-c output voltage was about 225 volts, and the current was about 5 ma. When the load was increased by substituting a 10,000-ohm resistor, the voltage dropped to about 215 volts as the current rose to about 22 ma. As you can see, an increase in load (current drain) causes a decrease in voltage available at the output of the filter circuit. If the load were further increased, the voltage would drop still further. This tube is designed to deliver a maximum of 70 ma.